Naked Goby

Gobiosoma bosc

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Photograph courtesy of the Gobioid Research Institute

DESCRIPTION

Taxonomy and Basic Description

The naked goby was first described by Lacepède in 1800 and given the name *Gobius bosc*. The genus was changed to *Gobiosoma*, and *Gobiosoma bosc* is the current scientific name. There are 9 to 10 broad, dark, vertical bars on the body, separated by narrow lighter interspaces (Dawson 1969). The common name reflects the lack of scales on the body. Dorsal fins are separate and pectoral fins are united to form a disk. Modal counts of fin elements are: dorsal spines (7), dorsal rays (13), anal rays (11), and pectoral rays (18).

Gobies represent the largest family of marine fishes, with more than 1,500 species worldwide (Murdy 2002). Like most gobies, naked gobies are small (less than 60 mm or 2.5 in.) in total length), secretive, bottom-dwelling fish that depend on structures—both non-living (burrow in substrate or woody debris) or living (oyster reef)—for habitat.

Status

In part, due to its small size, the naked goby is not of economic importance; however, it is of ecological importance. Although it is not a species of concern at the state or federal level, it has the potential to serve as an indicator species of estuarine health, in particular, the health of oyster reef habitat.

The naked goby is an estuarine-dependent species that is numerically dominant in oyster reef habitats and likely has an integral role in the estuarine food web. Only recently have oyster reefs been formally recognized as essential habitat for finfish and crustacean species of ecological and economic importance and given the designation of Essential Fish Habitat (Coen et al. 1999b). The naked goby is considered an estuarine-resident species (Jackson 1990; McGovern and Wenner 1990; Hoffman 1991) and, more specifically, a resident species of oyster reefs in tidepools and subtidal areas (Crabtree and Dean 1982; Coen et al. 1999b; Lehnert and Allen 2002).

In the Chesapeake Bay, larval naked gobies are the most abundant species in ichthyoplankton samples collected in lower salinity areas (Dovel 1971; Breitburg 1999), and, owing to their abundance, they may consume a significant portion of copepod production in tributaries of the Chesapeake Bay (Breitburg 1999). Larval naked gobies are prey for pelagic predators such as striped bass (*Morone saxatilis*), bluefish (*Pomatomus saltatrix*), and weakfish (*Cynoscion regalis*) that are associated with oyster reef habitat (Markle and Grant 1970; Harding and Mann 1999; Breitburg 1999). Four species of estuarine herons also feed on naked gobies; for snowy egrets, naked gobies represented 9% of the prey items consumed (Post 2008).

POPULATION SIZE AND DISTRIBUTION

The naked goby occurs along the Atlantic coast from Massachusetts to Florida, except for extreme south Florida (Robins et al. 1986). It also occurs in coastal areas from Florida through Campeche (Mexico) in the Gulf of Mexico (Murdy 2002). All life stages (egg through adult) are very common in estuarine waters throughout South Carolina.

No estimate of naked goby population size in South Carolina is available. While density estimates of naked gobies in oyster habitat are available (see below), improved estimates of the area of their preferred habitats (intertidal oyster habitat with tidepools and subtidal oyster habitat) need to be derived from ongoing statewide assessments of oyster reef distribution conducted by the SCDNR before naked goby population size can be estimated.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

The naked goby occurs in a variety of shallow estuarine habitats including oyster reefs, saltmarshes, seagrass beds (e.g. eelgrass, *Zostera marina*), and bare sand/mud substrate, although it is most abundant in tidepools and subtidal areas with oyster shell (Dahlberg and Conyers 1973; Crabtree and Dean 1982; Sogard and Able, 1991; Breitburg 1999; Harding and Mann 2000; Coen 2002; Lehnert and Allen 2002; Ross and Rohde 2004). In the study by Lehnert and Allen (2002) in North Inlet estuary near Georgetown, South Carolina, general trends were that: 1) numbers of fishes of all species were higher in trays of oyster shell placed in subtidal areas vs. intertidal areas; and 2) numbers of fishes were higher in shell-filled trays vs. trays with sand/mud substrate and empty trays. In intertidal ares of Charleston Harbor (South Carolina) and adjacent estuaries, Coen (2002) and Kingsley-Smith et al. (2012) found that the mean density of naked gobies was significantly greater on oyster reefs vs. marsh and mud/sand substrates. Naked gobies are more abundant in vegetated habitats (smooth cordgrass, *Spartina alterniflora*), seagrass beds, and sea lettuce (*Ulva* spp.) compared to unvegetated mud/sand (Sogard and Able 1991; Rozas and Minello 1998).

Density estimates of juveniles and adults in South Carolina estuaries are available from four sources. The mean density of juvenile and adult naked gobies in lift nets with oyster shells and oyster clumps in two tidepools along the North Edisto River (Charleston County, South Carolina) ranged from 8 to 25 individuals/m^2 (0.7 to 2.3 individuals/$ft.^2$) during June through October (Crabtree and Dean 1982). In both tidepools, the naked goby ranked first or second in mean catch and overall abundance. While investigating long-term oyster recruitment, predators, and parasites of this bivalve, Giotta (1999) found much higher densities of naked gobies. Using shell-filled trays placed in subtidal areas of Inlet Creek behind Sullivans Island in Charleston County, South Carolina, Giotta found 18 to 20 individuals per 0.42 m^2 (4.0 to 4.4 individuals/$ft.^2$) during mid-June through mid-January.

Lower densities have been reported from intertidal oyster habitat without tidepools. Coen (2002) reported mean densities of 4 and 9 individuals/m (0.4 and 0.8 individuals/ft.^{2}) during September and May, respectively, on natural oyster reefs in intertidal areas of Inlet Creek. During sampling in May, July, and October, Wenner et al. (1996) found an overall density of 1 goby/m^2 (0.09 individuals/ft.^{2}) on natural and artificial oyster reefs in intertidal areas of Inlet Creek and Tolers Cove in Charleston County, South Carolina. These studies show that intertidal oyster habitats without persistent pools of seawater at low tide are utilized less frequently by naked gobies. In addition, there is evidence that naked gobies have a preference for clumps of oysters over piled loose shell (Flynn and Paynter 2001).

Oyster habitat provides a site for the naked goby to feed and reproduce and offers protection from predators (Dahlberg and Conyers 1973; Crabtree and Middaugh 1982). The naked goby is an opportunistic microcarnivore that feeds on meiofauna (harpacticoid copepods) and macrofauna (amphipods, polychaetes) (D'Aguillo 2013). In addition, there is a diet shift from meiofauna (< 0.5 mm or 0.02 in.) to macrofauna (> 1.0 mm or 0.04 in.) that commences during the juvenile stage, at sizes < 20 mm (0.8 in.) standard length. Spawning occurs during late spring through summer in South Carolina and Georgia, based on the occurrence of adults nesting in oyster shells (Dahlberg and Conyers 1973; Lehnert and Allen 2002). Larval abundances in two South Carolina estuaries were found to be highest during summer (McGovern 1986; Jackson 1990). Adhesive eggs are most commonly laid inside hinged shells of clean, dead oysters in tidepools and subtidal areas (Dahlberg and Conyers 1973; Crabtree and Middaugh 1982). These nests of eggs are always in clumps of shells, never in single unattached shells (Crabtree and Middaugh 1982). The oyster shells chosen by the naked goby have a narrow gape so as to prevent predation on eggs (Crabtree and Middaugh 1982); shell gape is just large enough to allow entry of the fish (Dahlberg and Conyers 1973). Male naked gobies guard and aggressively defend the nest until larvae become free-swimming (Dahlberg and Conyers 1973). In subtidal areas, all nests remain submerged during low spring tides and nests seem to be located where tidal currents restrict siltation and stagnation at low tide (Dahlberg and Conyers 1973). In addition, late-stage larvae utilize the down-current side of high relief structure within oyster reefs, where reduced current velocity allows larvae to maintain their general position during high-flow portions of the tidal cycle (Breitburg et al. 1995).

The naked goby occurs over a wide range of salinities, from 0 to 45 parts per thousand (ppt), in estuaries along the Gulf of Mexico (Dawson 1969). In South Carolina, the salinity at capture locations ranged from 0.2 to 31.9 ppt in estuaries near the North Santee River (McGovern 1990), from 11 to 35 ppt in North Inlet estuary (Lehnert and Allen 2002), and from 0.8 to 36.2 ppt with an average of 18.1 ppt in the Charleston Harbor estuary (Roumillat unpubl. data[1]). High abundances of juvenile and adult naked gobies have been noted in subtidal oyster reef habitat in mesohaline (5 to 18 ppt) and polyhaline (18 to 30 ppt) areas of the North Inlet estuary (Lehnert and Allen 2002) and the Charleston Harbor estuary (Roumillat unpubl. data[1]). In the Ashley River/Charleston Harbor estuary, a similar distribution pattern was noted for larvae, as larval naked gobies were most abundant at the polyhaline site (Inlet Creek) (Jackson 1990). In contrast, studies in portions of the Chesapeake Bay with a large amount of freshwater inflow have shown that larval naked gobies are most abundant in oligohaline waters (less than 5 ppt) (Massman et al. 1963; Shenker et al. 1983; Campfield and Houde 2011) as a result of upriver transport in the salt wedge (Shenker et al. 1983).

Laboratory and field studies have shown that naked goby larvae require dissolved oxygen (DO) levels > 2 mg l^{-1}. A laboratory study by Saksena (1972) found that the median tolerance level (TL_{50}; 50% mortality after 24 hours) for DO is 1.30 mg l^{-1}. Laboratory studies have also shown that larvae strongly avoid DO levels < 1 mg l^{-1} and exhibit behavior indicating a reduced preference for a DO level of 2 mg l^{-1} (Breitberg 1994). A field study corroborated these results, showing that when the DO level at the bottom is low (< 2 mg l^{-1}), densities of naked goby larvae are less than one-third of those when the DO level is higher (Keister et al. 2000). In a laboratory study, at DO levels <2 mg l^{-1}, predation on naked goby larvae by sea nettle (*Chrysaora quinquecirrha*) scyphomedusa increases and predation by naked goby larvae decreases (Breitburg et al. 1994).

CHALLENGES

Naked goby population size is very likely linked to the quantity and quality of their preferred habitat, oyster reef in tidepools and subtidal areas. This species utilizes these reefs for its entire life cycle and requires hinged shells of clean, dead oysters with a narrow gape to ensure successful reproduction. Harvesting oysters reduces the vertical relief of reefs and removes the shells of dead oysters, thereby reducing the quantity and quality of habitat for reef-associated invertebrates and fishes. Breitburg et al. (2000) argued that harvest and conservation goals are compatible and that the same strategies will result in: 1) a sustainable harvest of the oyster resource; 2) increased filtration of estuarine waters; and 3) increased provision of structured habitat for invertebrates and fishes that utilize oyster reefs directly or indirectly.

CONSERVATION ACCOMPLISHMENTS

Significant and increased efforts at the South Carolina Department of Natural Resources (SCDNR) over the past 10+ years have sought to restore (create) and enhance oyster reef habitat throughout the State of South Carolina. Since 1994, researchers at the Marine Resources Division of SCDNR (e.g. Coen et al. 1999a,b; Hadley et al. 2010; Kingsley-Smith et al. 2012) have conducted research on evaluating the functioning of oyster reefs and related restoration approaches. One outcome of this early research was the establishment of the community-based South Carolina Oyster Restoration and Enhancement (SCORE) Program in 2000 (SCDNR(a) 2013). Oyster reef restoration and enhancement projects have represented cooperative efforts between the SCDNR and local and state partners including:

- Charleston Math and Science Hub
- The Nature Conservancy
- The South Carolina Aquarium
- The South Carolina Coastal Conservation League
- SCDNR - Coastal Education Office
- SCDNR - MRRI - Shellfish Research Section
- SCDNR - OFM-Shellfish Management Section
- South Carolina Sea Grant Consortium
- University of South Carolina - Baruch Laboratory
- University of South Carolina - Pritchard's Island
- USFWS Bear’s Bluff National Fish Hatchery

To generate the shell necessary for oyster habitat construction, a shell recycling program was initiated through the establishment of land-based drop-off points in the coastal counties of South Carolina (SCDNR(b) 2013). Shell recycling is critical to maintaining the State’s existing oyster

habitat. Returning shell to areas of oyster habitat serves to maintain the amount of hard substrate available to oyster larvae at the time of settlement. This program has expanded each year and now recycles more than 20,000 bushels of shell annually and maintains more than 25 drop-off sites at coastal and inland locations. Recycled shell is returned to the shoreline where it provides essential hard substrate for oyster attachment. A functioning oyster reef can develop in less than a year, and habitat attributes are often achieved even sooner.

The SCDNR (both the Shellfish Management Section and the Shellfish Research Section) enhances oyster habitat each year by replanting oyster shells and through the creation of new oyster reefs using alternative substrates (e.g. crab traps and oyster castles). Revenues from the sale of Saltwater Recreational Fishing Licenses are used to enhance 2-4 ac. of recreational harvest grounds annually. The Shellfish Management Section has also been constructing oyster reefs in the Charleston Harbor watershed under mitigation agreements. By 2015, about 15 ac. of oyster reefs will have been created under these agreements. In addition, the SCORE Program has worked with more than 150 local and state partners and more than 20,000 community volunteers to restore 2.7 ac. of oyster habitat between 2001 and 2013. The Shellfish Management Section has sought extramural funding to create up to two acres of oyster habitat annually, much of it in the ACE Basin. In 2012, through these collective efforts, more than 7 ac. of oyster habitat was created or enhanced.

In addition to restoring oyster reef habitat, the SCDNR continues to actively restore saltmarsh (smooth cordgrass), a secondary habitat utilized by the naked goby, through partnerships with South Carolina Sea Grant, Clemson Extension Service, and The Nature Conservancy. The SCDNR has discovered, through examination of temporal series of footprints of restored areas, that restoring saltmarsh is also an indirect benefit of restoring oyster reef habitat. Each acre of restored (or enhanced) oyster reef is estimated to result in an equivalent acreage of restored saltmarsh.

CONSERVATION RECOMMENDATIONS

- Determine population size and status of the naked goby.
- Continue to update statewide, high resolution maps of the distribution of oyster reefs, the primary habitat of the naked goby in South Carolina estuaries and tidal creeks.
- Improve our understanding of the relationships between oyster reef habitat quality and abundances of naked gobies (and other reef-associated fauna).
- Determine water quality requirements of the naked goby for all life history stages.
- Investigate aspects of the reproductive biology of the naked goby, including size/age at maturity, spawning season, and annual fecundity.
- Determine the effect of oyster harvesting on the abundance and diversity of reef-associated invertebrates and fishes.
- Protect water quality by encouraging communities to use Best Management Practices (BMPs).
- Continue habitat restoration and enhancement projects at the Marine Resources Division of SCDNR to increase the abundance of fishes and invertebrates that utilize oyster habitat for refuge, feeding and spawning.

MEASURES OF SUCCESS

The measurement of success is the continued abundance of this ecologically important species. Additionally, by monitoring abundance trends in this species, the SCDNR will be better able to assess habitat quality for several marine species.

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